The True Meshing Ratio of Skin Graft Meshers

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Skin meshing is frequently used in the coverage of extensive burn injuries as well as other skin and soft tissue wounds. This technique allows coverage of more extensive areas with smaller donor sites and prevents fluid from collecting beneath the skin grafts. The devices used to achieve this expansion differ in their technology and the use of skin carriers. In addition, many of the devices permit meshing at single or multiple ratios depending upon the device chosen. Although commonly used, there have been few definitive studies analyzing the actual expansion ratios achieved by many of these devices. The purpose of this study was to measure the actual meshing ratios achieved using some of the most commonly used skin meshers. The authors used split-thickness cadaveric skin samples provided by the regional tissue bank to compare the area of skin both before and after meshing to determine the actual expansion ratio and compared that with the ratio claimed by the device manufacturer. For all ratios greater than 1:1, the extent of actual expansion was significantly less than that expected for each device ($P < .001$). In addition, using devices that claimed to yield increasingly greater expansion ratios resulted in increasingly greater discrepancies between the area predicted by the device manufacturer and the actual surface area of skin ($P < .01$). These findings suggest that there is great variability in the expected and observed expansion ratios achieved by skin graft meshing devices. This has significant applicability to practice as it is likely to affect surgical decisions related to estimating the extent of donor area needed to cover skin and soft tissue defects. (J Burn Care Res 2014;35:257–260)

It has been the standard of practice for more than 30 years to mesh split-thickness skin grafts for the purpose of maximizing wound coverage when donor sites are limited, such as in patients with extensive full-thickness burn injuries. This method of skin expansion originated in Amsterdam in the early 20th century, but the first scientific article outlining this process was published by Tanner and Vandeput[1,2] in 1964. Although the technology and techniques have greatly improved since then, the basic premise for the technique remains.

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The two advantages of this technique are 1) greater coverage area with each individual graft (ie, skin meshed 2:1 would theoretically cover twice the area as the unmeshed graft), resulting in smaller donor sites and 2) graft "take" may be improved because of unlikely development of hematomas beneath the meshed graft compared with unmeshed grafts.[3] The disadvantages of meshed grafts are both cosmetic, because of the permanency of the mesh pattern in the healed grafted areas, as well as the delayed graft maturation. These disadvantages typically limit the use of meshed grafts to anatomic areas other than the face and hands, however, recent advances in skin meshing have shown that it may be possible to successfully use meshed grafts in these cosmetically sensitive areas.[4]

Although much research has been done in the area of meshing skin grafts, there have been no definitive studies in the past 20 years examining the actual expansion ratios achieved by these meshing devices. This study was designed to examine skin graft expansion by comparing the actual meshing ratio with the claimed meshing ratio of three different, commonly used skin meshers.

MATERIALS AND METHODS

Forty frozen samples of thawed allograft skin ranging from 0.010 to 0.015 inches in thickness were obtained from the regional skin bank. The skin samples ranged in length from 11.25 to 40 cm and the average width ranged from 3.58 to 10.3 cm. Each sample was randomly assigned to a mesher/ratio combination. The thawed skin was stretched to approximate surgical tension and pinned to a ¾-inch high-density polystyrene board with 1½-inch pins. Initial measurements of length and width were taken for each sample. Because each sample had varying widths along the length of the skin, multiple width measurements were taken approximately every 2 inches.

The devices studied were three Bioplasty meshers, the Zimmer Meshgraft™ II (Zimmer, Inc., Warsaw, IN), and the Collins mesher. The Bioplasty meshers studied were those with 1:1, 2:1, and 3:1 meshing ratios. The Zimmer mesher was studied using two dermacarrier ratios: 1.5:1 and 3:1. The Collins mesher was studied using a 4:1 meshing ratio. The skin was then meshed using the dermacarrier system of the Zimmer device, the applicable Bioplasty device, or the Collins mesher. The skin was again pinned using the previous technique and equivalent measurements recorded.

The estimated area before and after meshing was calculated by taking the average of the width measurements and multiplying by the length. The actual meshing ratio was calculated for each sample by dividing the postmeshing area by the premeshing area. This was done in order to compare each meshing device and ratio with all others. The percent difference was determined using the quotient of the difference between actual and claimed ratios to the claimed ratio $[(\text{Area}_{\text{claimed}} - \text{Area}_{\text{actual}})/\text{Area}_{\text{claimed}}]$. All six mesher/ratio combinations were studied individually to compare their actual and claimed meshing ratios. The combinations were also analyzed to determine whether trends existed between the ratios.

Statistical analysis was completed using SAS® 9.3 (SAS Institute, Inc., Cary, NC). Differences in experimental meshing ratios, as well as percent error among mesher/ratio combinations were done by one-way analysis of variance, with multiple comparisons by Tukey's test. Simple linear regression was used to determine the predictability of percent error from the estimated ratio.

RESULTS

Measurements of the pre- and postmeshing widths and lengths are listed in Table 1. Although the width of all of meshed grafts increased as the meshing ratio increased, the lengths tended to decrease as a result of the meshing process. This was true for all but the 1:1 Bioplasty meshing device.

The samples obtained from the regional skin bank were of varying sizes and randomly assigned a mesher/ratio combination. On average, the samples assigned to the 3:1 Zimmer group had shorter lengths. This resulted in smaller areas when compared with other sample groups. To account for this difference, the study was designed to only compare the area ratios, eliminating the effect of individual sample dimensions.

A significant decrease was seen in the actual and claimed ratios for all mesher/ratio combinations ($P < .001$). The pre- and post- areas and meshing ratios are listed in Table 2. The 1:1 expansion ratio was calculated to be 1:1.06, a 6% increase from the claimed 1:1 ratio. This was the only sample group that demonstrated greater expansion than the manufacturer's claimed ratio. The expansion ratio achieved with the Zimmer™ 1.5:1 mesher was 11% less than that expected and the expansion achieved with the Bioplasty 2:1 mesher was 14% less than expected. The expansions obtained using the Bioplasty and Zimmer™ 3:1 devices were 20 and 23% below the claimed ratio, respectively. The 4:1 expansion ratio claimed by the Collins manufacturer underestimated the postmesh area by 29% (Figure 1).

Table 1. Measurements of the mean pre- and postmeshing widths and lengths

Mesher	Expected Ratio	N	Mean Pre- Width	Mean Post- Width	Mean Pre- Length	Mean Post- Length
BioPlasty	1	5	6.08	6.38	24.40	24.60
Zimmer	1.5	6	7.22	9.85	23.17	22.63
BioPlasty	2	8	7.37	13.35	25.34	24.31
BioPlasty	3	9	6.86	16.99	25.14	24.25
Zimmer	3	6	7.19	16.97	13.54	13.25
Collins	4	6	6.95	20.58	22.42	21.58

All measurements are reported in centimeters.

Table 2. Claimed and actual expansion areas, ratios, and percent error from predicted expansion ratios

Mesher	Claimed Ratio	N	Mean Pre-Area	Mean Post-Area	Experimental Ratio (SD)	Percent Error
BioPlasty	1	5	139.55	147.61	1.06 (0.01)	–5.89
Zimmer	1.5	6	165.58	220.83	1.33 (0.04)	11.28
BioPlasty	2	8	178.60	307.68	1.72 (0.08)	13.92
BioPlasty	3	9	169.40	404.89	2.39 (0.1)	20.32
Zimmer	3	6	97.70	224.70	2.32 (0.1)	22.81
Collins	4	6	154.91	442.28	2.86 (0.15)	28.61

All areas are reported in square centimeters.

The difference in percent error among mesher/ratio combinations was statistically significant ($P < .001$). There was no uniform underexpansion, and each sample group had a statistically unique percent error. In addition, as the meshing ratio increased from 1:1 to 4:1, the percent error increased regardless of the device used. The 4:1 mesher had a significantly greater percent error than all other ratios ($P < .05$) and each ratio had a higher percent error than any lower meshing ratio ($P < .05$). The meshing ratio was also highly predictive of the percent error ($P < .01$).

DISCUSSION

Expansion of skin grafts using meshing devices has been a common surgical practice for nearly 50 years.[2] Previous studies of the expansion ratios achieved by these devices have been fairly consistent in demonstrating that they are quite variable in their ability to expand the skin to the degree predicted by the device manufacturers.[1,5,6] Our study was designed to eliminate all potential compounding factors to which this variability could be attributed and thus experimentally determine whether there was any consistent difference in claimed and actual expansion ratios.

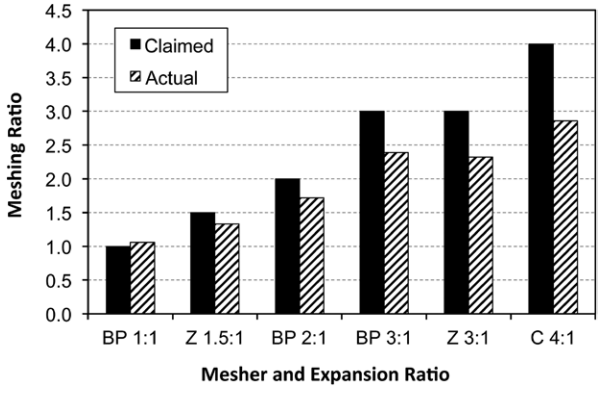

Figure 1. A graphical representation of the differences between claimed and actual meshing ratios for each mesher. *BP*, Bioplasty; *C*, Collins; *Z*, Zimmer.

Vandeput et al[1] determined through the use of mathematical models that skin expansion usually varied from that claimed by the manufacturer. Similarly, Peeters et al[6] found that the meshing process did not result in the expected expansion of the skin grafts. Although the previous investigators limited their study to the Zimmer mesher, it highlights the fact that this reduction in expansion has been observed for quite some time. More recently, Richard et al[5] performed a patient-based study that similarly demonstrated the deficient expansion of even the newer Bioplasty mesher. The study used fresh surgical specimens harvested from the thigh, which were measured quickly after harvest and subsequently used for patient wound coverage. The investigators postulated that the lack of expansion seen in the freshly harvested skin could have been attributed to the progressive shrinkage caused by the inherent elasticity of skin.

Because the results of the previous studies could have been attributed to factors other than the meshing process, the present study attempted to eliminate those factors and thus any deficient expansion would be entirely a result of the meshing process. In order to eliminate the progressive shrinking of freshly harvested skin, randomly selected frozen skin samples of similar thickness were used. Because these skin samples were not used clinically, more measurements could be taken and more time could be used to make the various measurements, resulting in higher accuracy. Further, because of the lack of time restraints, more observations could be made during the meshing process. It was noted early in the experimental portion of the study that the lengths were appearing to shorten as a result of the meshing process. Afterward, it was indeed found that for every combination except the 1:1 Bioplasty mesher, the length of the skin grafts decreased after meshing. Further study is needed to compare lengths between mesher/ratio combinations and to determine whether the loss of length significantly contributes to the loss in claimed expansion.

After attempting to eliminate all potential compounding factors and isolating the mesher as the only possible source of skin alteration, not one mesher studied produced the manufacturers' claimed expansion ratio ($P < .001$). In addition, as the claimed expansion ratio increased, the percent error of expansion also increased ($P < .05$). The knowledge that skin graft meshers do not produce the claimed expansion has applications that extend into the operating room. Particularly in the case of an autograft, it would be highly beneficial for surgeons to more accurately predict the necessary amount of skin needed based on wound area and the mesher used. This is currently extremely difficult because the various meshers do not provide the claimed uniform expansion needed to accurately calculate the amount of donor skin needed. The surgeon is therefore required to estimate the amount of donor skin required intraoperatively, resulting in either a shortage or excess of donor skin. If surgeons were able to more accurately calculate the necessary amount of donor skin, it would reduce the amount of speculation and greatly increase the use of valuable donor skin.

CONCLUSION

Although the basic concept and application of skin meshing has not significantly changed since its conception more than 100 years ago, there have been many advances in the methods and devices that are currently being used in today's operating rooms. These devices have been important in achieving autologous wound closure in patients with extensive burn injuries while limiting the need for donor sites. The manufacturers of these devices should provide surgeons with more accurate information regarding the expected expansion ratios achieved so that they can more effectively and efficiently use the donor skin.

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